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UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 CFR 1.53(b))

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First Named Inventor or Application Identifier	ISAMU UENO
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APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents.

ADDRESS TO: Assistant Commissioner for Patents
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1. [ ] Fee Transmittal Form *(Submit an original, and a duplicate for fee processing)*
2. [X] Specification — *Total Pages* 42
3. [X] Drawing(s) *(35 USC 113)* — *Total Sheets* 8
4. [X] Oath or Declaration — *Total Pages* 2
   - a. [ ] Newly executed (original or copy)
   - b. [X] Unexecuted for information purposes
   - c. [ ] Copy from a prior application (37 CFR 1.63(d)) *(for continuation/divisional with Box 17 completed)* ***[Note Box 5 below]***
     - i. [ ] DELETION OF INVENTOR(S) Signed Statement attached deleting inventor(s) named in the prior application, see 37 CFR 1.63(d)(2) and 1.33(b)
5. [ ] Incorporation By Reference *(useable if Box 4c is checked)* The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied under Box 4c, is considered as being part of the disclosure of the accompanying application and is hereby incorporated by reference therein.
6. [ ] Microfiche Computer Program *(Appendix)*
7. Nucleotide and/or Amino Acid Sequence Submission *(if applicable, all necessary)*
   - a. [ ] Computer Readable Copy
   - b. [ ] Paper Copy (identical to computer copy)
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ACCOMPANYING APPLICATION PARTS

8. [ ] Assignment Papers (cover sheet & document(s))
9. [ ] 37 CFR 3.73(b) Statement *(when there is an assignee)* [ ] Power of Attorney
10. [ ] English Translation Document *(if applicable)*
11. [ ] Information Disclosure Statement (IDS)/PTO-1449 [ ] Copies of IDS Citations
12. [ ] Preliminary Amendment
13. [X] Return Receipt Postcard (MPEP 503) *(Should be specifically itemized)*
14. [ ] Small Entity Statement(s) [ ] Statement filed in prior application Status still proper and desired
15. [ ] Certified Copy of Priority Document(s) *(if foreign priority is claimed)*
16. [ ] Other: ______________________

17. If a CONTINUING APPLICATION, *check appropriate box and supply the requisite information:*

[ ] Continuation [ ] Divisional [ ] Continuation-in-part (CIP) of prior application No. ___/__________

18. CORRESPONDENCE ADDRESS

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CLAIMS	(1) FOR	(2) NUMBER FILED	(3) NUMBER EXTRA	(4) RATE	(5) CALCULATIONS
	TOTAL CLAIMS (37 CFR 1.16(c))	39-20 =	19	X $ 18.00 =	$ 342.00
	INDEPENDENT CLAIMS (37 cfr 1.16(b))	3-3 =	0	X $ 78.00 =	$ 0.00
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				BASIC FEE (37 CFR 1.16(a))	$ 760.00
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19. Small entity status

a. ☐ A Small entity statement is enclosed

b. ☐ A small entity statement was filed in the prior nonprovisional application and such status is still proper and desired.

c. ☐ Is no longer claimed.

20. ☒ A check in the amount of $ 1,362.00 to cover the filing fee is enclosed.

21. ☐ A check in the amount of $ ____________ to cover the recordal fee is enclosed.

22. The Commissioner is hereby authorized to credit overpayments or charge the following fees to Deposit Account No. 06-1205:

a. ☒ Fees required under 37 CFR 1.16.

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SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT REQUIRED	
NAME	Abigail F. Cousins (Reg. No. 29,292)
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DATE	January 22, 1999

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Image Pickup Apparatus

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to an image pickup apparatus for generating a color image signal from light incident from a color filter array, to an image signal read method of reading an image signal from the image pickup apparatus; to a computer process method of generating an image signal, to a computer readable storage medium storing programs, to a processing apparatus for obtaining an image signal; and to an image pickup system including the image pickup apparatus and the processing apparatus.

Related Background Art

In order to obtain a color image signal in an image pickup apparatus, light is incident upon image pickup elements via a color filter. The color filter includes a primary color filter and a complementary color filter. The primary color filter has three colors, red, green, and blue, whereas the complementary color filter has four colors, cyan, yellow, magenta, and green. A cyan color filter intercepts only red color in the visible light range, an yellow color filter intercepts only blue color in the visible light range, a magenta color filter intercepts only green color in the visible light range, and a green color

filter transmits only green light.

In the case of complementary color filters, a luminance signal Y is given by:

$$Y = Ye + G + Cy + Mg \quad \ldots (1),$$

a blue color difference signal is given by:

$$CB = (G + Ye) - (Mg + Cy) \quad \ldots (2),$$

and a red color difference signal is given by:

$$CR = (Cy + G) - (Ye + Mg) \quad \ldots (3)$$

wherein Cy is a signal picked up by image pickup elements via cyan color filters, Ye is a signal picked up by image pickup elements via the yellow color filters, Mg is a signal picked up by image pickup elements via magenta color filters, and G is a signal picked up by image pickup elements via green color filters.

Fig. 1 shows a pattern of color filters according to a first conventional example. This pattern has a periodicity of two pixels in the horizontal direction and four pixels in the vertical direction. With this color filter pattern, the luminance signal Y can be obtained through the equation (1) by using Cy, Ye, Mg, and G in a block of 2 × 2 pixels, two pixels in the horizontal direction and two pixels in the vertical direction. Similarly the blue and red color difference signals CB and CR can be obtained through the equations (2) and (3) by using Cy, Ye, Mg, and G in the block of 2 × 2 pixels.

Fig. 2 shows a pattern of color filters according to a second conventional example. This pattern has a periodicity of two pixels in the horizontal direction and four pixels in the vertical direction. With this color filter pattern, the luminance signal Y can be obtained through the equation (1) by using Cy, Ye, Mg, and G in a block of 2 × 2 pixels, two pixels in the horizontal direction and two pixels in the vertical direction. Similarly the blue and red color difference signals CB and CR can be obtained through the equations (2) and (3) by using Cy, Ye, Mg, and G in the block of 2 × 2 pixels.

A digital still camera with an image pickup apparatus reads an image at high speed with a sacrifice of resolution before an image is photographed. In accordance with the image signal read at high speed, an image is displayed in a finer such as a liquid crystal finder, an iris is adjusted, a white balance is adjusted, or other preliminary operations are performed. However, with a combination of the color filter layout shown in Fig. 1 and a conventional image pickup apparatus CCD, even if the pixel signal is read at high speed with a sacrifice of resolution by thinning every second pixel in the vertical direction, for example, only cyan and yellow signals are obtained so that the while balance cannot be adjusted in accordance with outputs of the image pickup elements.

Also with the combination of the color filter layout shown in Fig. 1 and a conventional image pickup apparatus CCD, data of two adjacent pixels in the vertical direction is added and thereafter transferred in the image pickup apparatus and output therefrom. Therefore, paired image data is output from the image pickup apparatus. More specifically, referring to Fig. 1, a pair of data of pixels (C1, R1) and (C1, R2) is output, then a pair of data of pixels (C2, R1) and (C2, R2) is output, then pairs of data of column pixels in the rows R1 and R2 are sequentially output. Next, a pair of data of pixels (C1, R3) and (C1, R4) is output, then a pair of data of pixels (C2, R3) and (C2, R4) is output, then pairs of data of column pixels in the rows R3 and R3 are sequentially output. Since these outputs are used, the calculation of the equation (2) can be made, for example, for the rows R1 and R2, but it cannot be made for the rows R3 and R4. Similarly, the calculation of the equation (3) can be made, for example, for the rows R3 and R4, but it cannot be made for the rows R1 and R2. Therefore, the color difference signal for each color can be obtained only from one row among the four rows of image pickup elements so that the resolution of the color difference signal lowers in the vertical direction.

With the combination of the color filter layout shown in Fig. 2 and a conventional image pickup

apparatus CCD, a signal read in a high speed read mode can be used for adjusting the white balance.

With the combination of the color filter layout shown in Fig. 2 and a conventional image pickup apparatus CCD, data of two adjacent pixels in the vertical direction is added and thereafter transferred in the image pickup apparatus and output therefrom. Therefore, paired image data is output from the image pickup apparatus. More specifically, referring to Fig. 2, a pair of data of pixels (C1, R1) and (C1, R2) is output, then a pair of data of pixels (C2, R1) and (C2, R2) is output, then pairs of data of column pixels in the rows R1 and R2 are sequentially output. Next, a pair of data of pixels (C1, R3) and (C1, R4) is output, then a pair of data of pixels (C2, R3) and (C2, R4) is output, then pairs of data of column pixels in the rows R3 and R3 are sequentially output. Since these outputs are used, the calculation of the equation (2) can be made, for example, for the rows R1, R2, R3, and R4, but it cannot be made for the rows R5, R6, R7, and R8. Similarly, the calculation of the equation (3) can be made, for example, for the rows R5, R6, R7, and R8, but it cannot be made for the rows R1, R2, R3, and R4. Therefore, the color difference signal for each color can be obtained only from two rows among the eight rows of image pickup elements so that the resolution of the color difference signal lowers in the vertical

direction.

SUMMARY OF THE INVENTION

It is an object of the present invention to obtain an image signal having a high resolution both in the horizontal and vertical directions.

It is another object of the present invention to provide a multi-mode such as a mode of outputting an image signal at high speed which signal can be used for simple color display, autofocus, white balance adjustment and a mode of outputting an image signal having a high resolution.

In order to achieve the above objects, an image pickup apparatus according to an embodiment of the invention comprises: a plurality of pixels; a color filter array of four colors disposed on the plurality of pixels, wherein said color filter array has a periodicity of two rows × two columns, and colors of four color filters in a periodical unit of two rows × two columns are all different from each other.

An image pickup apparatus according to another embodiment of the invention comprises: a plurality of pixels; a color filter array of four colors disposed on the plurality of pixels; first calculating means for calculating a difference between an average signal of a first row, first column signal and a first row, second column signal in an area of two rows × two columns and

an average signal of a second row, first column signal and a second row, second column signal in the area of two rows × two columns; and second calculating means for calculating a difference between an average signal of a first row, first column signal and a second row, first column signal in the area of two rows × two columns and an average signal of a first row, second column signal and a second row, second column signal in the area of two rows × two columns.

An image pickup apparatus according to another embodiment comprises; a plurality of pixels; a color filter array disposed on the plurality of pixels and having a periodicity of two rows × two columns; and calculating means for calculating two color difference signals from each color filter of two rows × two columns in the color filter array having the periodicity of two rows × two columns.

Other objects and features of the present invention will become more apparent from the following detailed description of embodiments when read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows a pattern of conventional color filters.

Fig. 2 shows another pattern of conventional color filters.

Fig. 3 shows a pattern of color filters according to a first embodiment of the invention.

Fig. 4 is a diagram illustrating a read method according to the first embodiment of the invention.

Fig. 5 is a circuit diagram of an image pickup apparatus according to a second embodiment of the invention.

Fig. 6 is a timing chart illustrating the operation of the image pickup apparatus shown in Fig. 5.

Fig. 7 is a circuit diagram of an image pickup apparatus according to a third embodiment of the invention.

Fig. 8 is a timing chart illustrating the operation of the image pickup apparatus shown in Fig. 6.

Fig. 9 is a circuit diagram of an image pickup apparatus according to a fourth embodiment of the invention.

Fig. 10 is a timing chart illustrating the operation of the image pickup apparatus shown in Fig. 9.

Fig. 11 is a diagram showing an image pickup system with an image pickup apparatus, according to a fifth embodiment of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig. 3 shows a pattern of color filters according to the first embodiment of the invention. This pattern has a periodicity of two pixels in the horizontal direction and two pixels in the vertical direction. In a pattern of two pixels in the horizontal direction and two pixels in the vertical direction, the first row has G and Ye color filters disposed in this order from the left, and the second row has Cy and Mg color filters disposed in this order from the left. The pattern of color filters may be reversed right and left, or up and down.

The luminance signal Y, blue color difference signal CB, and red color difference signal CR can be calculated respectively from the equations (2) and (3) by using Cy, Ye, Mg, and G signals in various color filter patterns. Fig. 4 shows a pattern of color filters constituted of a fundamental pattern of two pixels in the horizontal direction and two pixels in the vertical direction. With reference to Fig. 4, particular read methods will be described.

1st Read Method:

Color difference signals CB are calculated from adjacent pairs of a series of signals output from image pickup elements, the series being:

(G1 + Ye1), (Cy1 + Mg1), (G2 + Ye2), (Cy2 + Mg2),
(G3 + Ye3), (Cy3 + Mg3), (G4 + Ye4), (Cy4 + Mg4),...

and the color difference signals CD being, for example:

CB1 = (G1 + Ye1) - (Cy1 + Mg1)

CB2 = (G2 + Ye2) - (Cy2 + Mg2)

CB3 = (G3 + Ye3) - (Cy3 + Mg3)

CB4 = (G4 + Ye4) - (Cy4 + Mg4).

Color difference signals CR are calculated from adjacent pairs of a series of signals output from image pickup elements, the series being:

(G1 + Cy1), (Ye1 + Mg1), (G2 + Cy2), (Ye2 + Mg2), (G3 + Cy3), (Ye3 + Mg3), (G4 + Cy4), (Ye4 + Mg4),...

and the color difference signals CR being, for example:

CR1 = (G1 + Cy1) - (Ye1 + Mg1)

CR2 = (G2 + Cy2) - (Ye2 + Mg2)

CR3 = (G3 + Cy3) - (Ye3 + Mg3)

CR4 = (G4 + Cy4) - (Ye4 + Mg4).

With the first read method, the color difference signals CB and CR each can be obtained from two pixels in the horizontal direction and two pixels in the vertical direction, resulting in a high resolution.

2nd Read Method:

A luminance signal Y is calculated from a series of signals output from image pickup elements, the series being:

(G1 + Cy1 + G3 + Cy3), (Ye1 + Mg1 + Ye3 + Mg3), (G2 + Cy2 + G4 + Cy4), (Ye2 + Mg2 + Ye4 + Mg4),...

and the luminance signals Y being, for example:

Y1 = (G1 + Cy1 + G3 + Cy3) + (Ye1 + Mg1 + Ye3 + Mg3)

Y2 = (G2 + Cy2 + G4 + Cy4) + (Ye2 + Mg2 + Ye4 + Mg4).

With the second read method, one luminance signal Ye is obtained for every two pixels in the horizontal direction. The level of the luminance signal Y is high. The luminance signal Y generated by this method is suitable for an autofocus detecting signal particularly when an object has a high horizontal resolution such as a fine vertical stripe pattern and has a low luminance.

3rd Read Method:

A luminance signal Y is calculated from a series of signals output from image pickup elements, the series being:

(G1 + Ye1 + G2 + Ye2), (Cy1 + Mg1 + Cy2 + Mg2),
(G3 + Ye3 + G4 + Ye4), (Cy3 + Mg3 + Cy4 + Mg4),...

and the luminance signals Y being, for example:

Y1 = (G1 + Ye1 + G2 + Ye2) + (Cy1 + Mg1 + Cy2 + Mg2)
Y2 = (G3 + Ye3 + G4 + Ye4) + (Cy3 + Mg3 + Cy4 + Mg4).

With the third read method, one luminance signal Ye is obtained for every two pixels in the vertical direction. The level of the luminance signal Y is high in the vertical direction. The luminance signal Y generated by this method is suitable for an autofocus detecting signal particularly when an object has a high horizontal resolution such as a fine horizontal stripe pattern.

4th Read Method:

Color difference signals CB are calculated from

adjacent pairs of a series of signals output from image pickup elements, the series being:

(G1 + Ye1), (Cy1 + Mg1), (G2 + Ye2), (Cy2 + Mg2),...

and the color difference signals CB being, for example:

CB1 = (G1 + Ye1) - (Cy1 + Mg1)

CB2 = (G2 + Ye2) - (Cy2 + Mg2).

Color difference signals CR are calculated from adjacent pairs of a series of signals output from image pickup elements, the series being:

(G3 + Cy3), (Ye3 + Mg3), (G4 + Cy4), (Ye4 + Mg4),...

and the color difference signals CR being, for example:

CR1 = (G3 + Cy3) - (Ye3 + Mg3)

CR2 = (G4 + Cy4) - (Ye4 + Mg4).

With the fourth read method, a color difference line sequential signal can be obtained. The fourth read method is suitable for a moving image object, because the number of read signals is a half of the first read method.

5th Read Method:

Color difference signals CB are calculated from adjacent pairs of a series of signals output from image pickup elements, the series being:

(G1 + Ye1), (Cy1 + Mg1), (G2 + Ye2), (Cy2 + Mg2),...

and the color difference signals CB being, for example:

CB1 = (G1 + Ye1) - (Cy1 + Mg1)

CB2 = (G2 + Ye2) - (Cy2 + Mg2).

Color difference signals CR are calculated from

adjacent pairs of a series of signals output from image pickup elements, the series being:

(G2 + Cy2), (Ye2 + Mg2), (G4 + Cy4), (Ye4 + Mg4),...

and the color difference signals CR being, for example:

CR1 = (G2 + Cy2) - (Ye2 + Mg2)

CR2 = (G4 + Cy4) - (Ye4 + Mg4).

The fifth read method is suitable for a moving image object.

An image signal can be read at high speed because the number of read color difference signals of pixels is a half of the first read method.

6th Read Method:

Color difference signals CB are calculated by the method similar to the fifth read method.

Color difference signals CR are calculated from adjacent pairs of a series of signals output from image pickup elements, the series being:

(G1, Cy1), (Ye1, Mg1), (G3, Cy3), (Ye3, Mg3),...

and the color difference signals CR being, for example:

CR1 = (G1 + Cy1) - (Ye1 + Mg1)

CR2 = (G3 + Cy3) - (Ye3 + Mg3).

The sixth read method is suitable for a moving image object.

An image signal can be read at high speed because the number of read color difference signals of pixels is a half of the first read method.

7th Read Method:

Color difference signals CB are calculated by the method similar to the fifth read method.

Color difference signals CR are calculated from adjacent pairs of a series of signals output from image pickup elements, the series being:

(G1, Cy1), (Ye1, Mg1), (G2, Cy2), (Ye2, Mg2),...

and the color difference signals CR being, for example:

$$CR1 = (G1 + Cy1) - (Ye1 + Mg1)$$

$$CR2 = (G2 + Cy2) - (Ye2 + Mg2).$$

The sixth read method is suitable for a moving image object.

An image signal can be read at high speed because the number of read color difference signals of pixels is a half of the first read method.

The color difference signals CB and CR are obtained from the same area.

8th to 11th Read Methods:

Color difference signals CB are calculated from adjacent pairs of a series of signals output from image pickup elements, the series being:

(G1 + Ye1), (Cy1 + Mg1), (G3 + Ye3), (Cy3 + Mg3),...

and the color difference signals CB being, for example:

$$CB1 = (G1 + Ye1) - (Cy1 + Mg1)$$

$$CB2 = (G3 + Ye3) - (Cy3 + Mg3).$$

The color difference signals CR are calculated by the similar method to the fourth to seventh read methods. The eighth to eleventh read methods are

suitable for a moving image object.

An image signal can be read at high speed because the number of read color difference signals of pixels is a half of the first read method.

12th Read Method:

Color difference signals CB are calculated from adjacent pairs of a series of signals output from image pickup elements, the series being:

(G1 + Ye1), (Cy1 + Mg1),...

and the color difference signal CB being, for example:

CB1 = (G1 + Ye1) - (Cy1 + Mg1)

Color difference signals CR are calculated from adjacent pairs of a series of signals output from image pickup elements, the series being:

(G4, Cy4), (Ey4, Mg4),...

and the color difference signal CR being, for example:

CR1 = (G4 + Cy4) - (Ye4 + Mg4)

The twelfth method is suitable for a moving image object.

An image signal can be read at high speed because the number of read color difference signals of pixels is a quarter of the first read method.

13th Read Method:

Luminance signals Y are calculated from adjacent pairs of a series of signals output from image pickup elements, the series being:

(G1 + Ye1), (Cy1 + Mg1), (G2 + Ye2), (Cy2 + Mg2),

(G3 + Ye3), (Cy3 + Mg3), (G4 + Ye4), (Cy4 + Mg4),...
and the luminance signals Y being, for example:

$$Y1 = (G1 + Ye1) + (Cy1 + Mg1)$$

$$Y2 = (G2 + Ye2) + (Cy2 + Mg2)$$

$$Y3 = (G3 + Ye3) + (Cy3 + Mg3)$$

$$Y4 = (G4 + Ye4) + (Cy4 + Mg4).$$

14th Read Method:

Luminance signals Y are calculated from adjacent pairs of a series of signals output from image pickup elements, the series being:

(G1 + Cy1), (Ye1 + Mg1), (G2 + Cy2), (Ye2 + Mg2),
(G3 + Cy3), (Ye3 + Mg3), (G4 + Cy4), (Ye4 + Mg4),...
and the luminance signals Y being, for example:

$$Y1 = (G1 + Cy1) + (Ye1 + Mg1)$$

$$Y2 = (G2 + Cy2) + (Ye2 + Mg2)$$

$$Y3 = (G3 + Cy3) + (Ye3 + Mg3)$$

$$Y4 = (G4 + Cy4) + (Ye4 + Mg4).$$

The above read methods may be used while pixels are read by thinning them in the unit of a fundamental pattern or a plurality of fundamental pattern to thereby speed up a read operation.

Next, a circuit structure realizing the read method of the first embodiment using CMOS sensors as an example of image pickup elements, according to the second embodiment of the invention, will be described.

Fig. 5 is a circuit diagram showing the structure of a CMOS sensor of the second embodiment. In this

embodiment, the CMOS sensor includes: a first output series for outputting a difference between an average value of detection light amounts of two pixels adjacent in the vertical direction in one column and an average value of detection light amounts of two pixels adjacent in the vertical direction in the next column; and a second output series for outputting a difference between an average value of detection light amounts of two pixels adjacent in the horizontal direction in one row and an average value of detection light amounts of two pixels adjacent in the horizontal direction in the next row. Therefore, the CMOS sensor of this embodiment can use the first read method.

Referring to Fig. 5, reference numeral 1 represents a vertical scan circuit for generating an enable signal which enables a control signal of each row, the enable signal sequentially becoming active in the vertical direction. Reference numeral 100 represents a photodiode serving as a photodetector for converting incidence light into electric charges. Reference numeral 101 represents a transfer transistor for transferring the electric charges generated by the photodiode 100 to a floating diffusion region 101 which temporarily stores the transferred electric charges. Reference numeral 103 represents a reset transistor for discharging electric charges accumulated in the gate of an amplifier transistor 104. Reference numeral 121

represents a switching transistor. The elements 100 to 104, and 121 constitute one pixel. Reference numeral 112 represents a constant current source transistor which is activated by a voltage applied to a terminal 7. Reference numeral 105 represents a transistor for discharging electric charges in capacitors 109, 110, 117, and 118. Reference numeral 106 represents a current distribution division transistor for connecting the source of the transistor 104 to the capacitor 109. Reference numeral 107 represents a current distribution transistor for connecting the source of the transistor 104 to the capacitor 110. The capacitors 109 and 110 function as a line memory which is charged by a voltage supplied from the transistor 104. Reference numeral 108 represents an averaging transistor for averaging the electric charges in the capacitors 109 and 110. Reference numeral 111 represents a switching transistor for applying a voltage of the line memory 109 to a buffer 123 at the front stage of a differential amplifier 122 which amplifies a difference between voltages across the capacitors 109 and 109'. Reference numeral 113 represents a switching transistor for connecting the source of the transistor 104 to a capacitor 117. Reference numeral 114 represents a switching transistor for connecting the source of the transistor 104 to a capacitor 118. The capacitors 117 and 118 are charged by a current supplied from the

source of the transistor 104. Reference numeral 115 represents a switching transistor for controlling to average the electric charges stored in the capacitors 117 and 117'. Reference numeral 116 represents a switching transistor for controlling to average the electric charges stored in the capacitors 118 and 118'. Reference numeral 119 represents a switching transistor for supplying a voltage of the line memory 117 to a buffer 129 at the front stage of a differential amplifier 127 which amplifies a difference between voltages across the capacitors 117 and 118'. The constant current source transistor 112 is activated in the unit of a row, and paired with the transistor 104 to constitute an amplifier.

Fig. 6 is a timing chart illustrating an operation of the CMOS sensor shown in Fig. 5. With reference to Figs. 5 and 6, the operation of the CMOS sensor shown in Fig. 5 will be described.

At timing T201, a pulse applied to a terminal 11 takes a high state, and pulses applied to M terminals 30, 31, 50, and 51 take the high state. Therefore, the line memories 109, 110, 117, and 118 are reset to initial potentials. At the same time, a start pulse applied to a terminal 2 of the vertical scan circuit 1 and a scan pulse applied to a terminal 3 take the high level, so that the vertical scan circuit 1 starts scanning to select the first row. A high level pulse

is applied to a terminal 8 to reset the floating diffusion regions of the pixel area. At timing T202, a reset pulse at the terminal 8 falls so that the floating diffusion regions of first row pixels are made in an electrically floating state. At timing T203, a high level pulse is applied to a terminal 9 so that electric charges are transferred from photodiodes of the first row to the floating diffusion regions. At timing T204, a high level pulse is applied to terminals 10, 30, and 50 so that a voltage proportional to light amounts detected with the photodetectors of the first row is read to the capacitors 109 and 117 via the amplifier 104. At timing T205, the vertical scan pulse 3 falls. At timing T206, the vertical scan pulse 3 again rises to select the second row. At timing T207, a reset pulse false so that the floating diffusion regions of pixels of the second row are made in an electrically floating state. At timing T208, similar to timing T203, a high level pulse is applied to the terminal 9 so that electric charges are transferred from photodiodes of the second row to the floating diffusion regions. At timing T209, similar to timing T204, a high level pulse is applied to terminals 10, 30, and 51 so that a voltage proportional to light amounts detected with the photodetectors of the second row is read to the capacitors 110 and 118 via the amplifier 104 of the second row. At timing T210, a

high level pulse is applied to terminals 40, 60, and 61 to average the electric charges on the line memories. At timing T211, a horizontal scan circuit 4 starts scanning so that averaged voltages are sequentially applied in the horizontal direction to the differential amplifiers 122 and 127. The differential amplifiers 122 and 127 outputs a blue color difference signal CB and a red color difference signal CR. By connecting adders (not shown) made of an operational amplifier or the like to the terminals 70 and 71 and to the terminals 80 and 81, luminance signals can be output.

If the averaging operation by the averaging transistor 108 is not performed and the signals of all rows are temporarily stored in the capacitor 109, an output signal of each pixel in the odd column can be obtained from the output terminal 71, and an output signal of each pixel in the even column can be obtained from the output terminal 70.

Fig. 7 is a circuit diagram showing the structure of a CMOS sensor of the third embodiment. In this embodiment, the CMOS sensor includes an output series for outputting an average value of detection light amounts of two pixels adjacent in the horizontal direction or an average of detection light amounts of four pixels adjacent in the horizontal direction. Therefore, the CMOS sensor of this embodiment can use the third read method by summing the two outputs of the

CMOS sensor.

In Fig. 7, like elements to those similar to the CMOS sensor of the second embodiment are represented by using identical reference numerals, and the duplicated description thereof is omitted. Reference numeral 301 represents a switching transistor for controlling to average electric charges accumulated in capacitors 109 and 109'. Reference numeral 302 represents a switching transistor for controlling to average electric charges accumulated in capacitors 110 and 110'. Reference numeral 301' represents a switching transistor for controlling to average electric charges accumulated in capacitors 109" and 109"'. Reference numeral 302' represents a switching transistor for controlling to average electric charges accumulated in capacitors 110" and 110"'. Reference numeral 303 represents a switching transistor for controlling to average electric charges accumulated in the capacitors 109' and 109". Reference numeral 304 represents a switching transistor for controlling to average electric charges accumulated in the capacitors 110' and 110". If the switching transistors 301, 301', and 303 are operated synchronously, the electric charges stored in the capacitors 109, 109', 109", and 109"' are averaged. For example, if after or when the switching transistors 301 and 301' are turned on, the switching transistor 303 is turned on, these transistors average the

electric charges stored in the capacitors 109, 109', 109", and 109"'. If the switching transistors 302, 302', and 304 are operated synchronously, these transistors average the electric charges stored in the capacitors 110, 110', 110", and 110"'. Namely, if after or when the switching transistors 302 and 304' are turned on, the switching transistor 304 is turned on, these transistors average the electric charges stored in the capacitors 110, 110', 110", and 110"'.

Fig. 8 is a timing chart illustrating an operation of the CMOS sensor shown in Fig. 7. With reference to Figs. 7 and 8, the operation of the CMOS sensor shown in Fig. 7 will be described.

At timing T401, a start pulse applied to a terminal 2 of the vertical scan circuit 1 and a scan pulse applied to a terminal 3 take the high level, so that the vertical scan circuit 1 starts scanning to select the first row. A high level pulse is applied to a terminal 8 to reset the floating diffusion regions of the pixel area. At timing T402, a reset pulse at the terminal 8 falls so that the floating diffusion regions of first row pixels are made in an electrically floating state. At timing T403, a high level pulse is applied to a terminal 9 so that electric charges in the photodetectors of the first row are transferred to the floating diffusion regions. At timing T404, a high level pulse is applied to terminals 10 and 50 so that a

voltage proportional to light amounts detected with the photodetectors of the first row is read to the capacitor 109 via the amplifier 104. At timing T405, the vertical scan pulse 3 rises. At timing T406, the vertical scan pulse 3 again falls to select the second row. At timing T407, a reset pulse false so that the floating diffusion regions of pixels of the second row are made in an electrically floating state. At timing T408, similar to timing T403, a high level pulse is applied to the terminal 9 so that electric charges are transferred from photodiodes of the second row to the floating diffusion regions. At timing T409, similar to timing T404, a high level pulse is applied to terminals 10, and 51 so that a voltage proportional to light amounts detected with the photodetectors of the second row is read to the capacitor 110 via the amplifier 104 of the second row. At timing T410, a high level pulse is applied to terminals 60, 61, 90, and 91 to average the electric charges in the capacitors 109, 109', 109", and 109"' on the line memories and to average the electric charges in the capacitors 110, 110', 110", and 110"' on the line memories. At timing T411, a horizontal scan circuit 4 starts scanning so that averaged voltages are sequentially output in the horizontal direction. Since a luminance signal is output in this embodiment, only one output terminal 16 is used. If a plurality of output terminals like those

shown in Fig. 7 are used, color difference signals can be obtained.

Fig. 9 is a circuit diagram showing the structure of a CMOS sensor of the fourth embodiment. In this embodiment, the CMOS sensor includes an output series for outputting an average value of detection light amounts of two pixels adjacent in the vertical direction or an average of detection light amounts of four pixels adjacent in the vertical direction. Therefore, the CMOS sensor of this embodiment can use the second read method by summing the two outputs of the CMOS sensor.

In Fig. 9, like elements to those similar to the CMOS sensor of the third embodiment are represented by using identical reference numerals, and the duplicated description thereof is omitted. Reference numerals 501, 502, 503, and 504 represent current distribution transistors for distributing current supplied from a transistor to capacitors 508, 109, 510, and 511. The capacitor 508 stores signals from first row photodetectors, the capacitor 509 stores signals from second row photodetectors, the capacitor 510 stores signals from third row photodetectors, and the capacitor 511 stores signals from fourth row photodetectors. Reference numeral 505 represents a switching transistor for controlling to average electric charges accumulated in the capacitors 508 and

509. Reference numeral 506 represents a switching transistor for controlling to average electric charges accumulated in the capacitors 509 and 510. Reference numeral 507 represents a switching transistor for controlling to average electric charges accumulated in the capacitors 510 and 511. If the switching transistors 505, 506, and 507 are operated synchronously, the electric charges stored in the capacitors 508, 509, 510, and 511 are averaged. For example, if after or when the switching transistors 505 and 507 are turned on, the switching transistor 506 is turned on, these transistors average the electric charges stored in the capacitors 508, 509, 610, and 511.

Fig. 10 is a timing chart illustrating an operation of the CMOS sensor shown in Fig. 9. With reference to Figs. 9 and 10, the operation of the CMOS sensor shown in Fig. 9 will be described.

At timing T601, a start pulse applied to a terminal 2 of the vertical scan circuit 1 and a scan pulse applied to a terminal 3 take the high level, so that the vertical scan circuit 1 starts scanning to select the first row. A high level pulse is applied to a terminal 8 to reset the floating diffusion regions of the pixel area. At timing T602, a reset pulse at the terminal 8 falls so that the floating diffusion regions of first row pixels are made in an electrically

floating state. At timing T603, a high level pulse is applied to a terminal 9 so that electric charges in the photodetectors of the first row are transferred to the floating diffusion regions. At timing T604, a high level pulse is applied to terminals 10 and 30 so that a voltage proportional to light amounts detected with the photodetectors of the first row is read to the capacitor 508. At timing T605, the vertical scan pulse 3 rises. At timing T606, the vertical scan pulse 3 again rises to select the second row. At timing T607, a reset pulse falls so that the floating diffusion regions of pixels of the second row are made in an electrically floating state. At timing T608, similar to timing T603, a high level pulse is applied to the terminal 9 so that electric charges are transferred from photodiodes of the second row to the floating diffusion regions. At timing T609, similar to timing T604, a high level pulse is applied to terminals 10, and 31 so that a voltage proportional to light amounts detected with the photodetectors of the second row is read to the capacitor 509. Similarly at timing T610, a high level pulse is applied to terminals 10 and 32 so that a voltage proportional to light amounts detected with the photodetectors of the third row is read to the capacitor 510. Similarly at timing T611, a high level pulse is applied to terminals 10 and 33 so that a voltage proportional to light amounts detected with the photodetectors of the fourth row is read to the capacitor 511.

photodetectors of the fourth row is read to the capacitor 511. At timing T612, a high level pulse is applied to the terminals 40 and 41 to average the electric charges in the capacitors 508, 509, 510, and 511 on the line memories. At timing T613, a horizontal scan circuit 4 starts scanning so that averaged voltages are sequentially output in the horizontal direction. Voltages proportional to average values of light amounts detected with the photodetectors of the first to fourth rows are sequentially output from an output terminal 70.

If the averaging operation by the switching transistor 506 is not performed, an average value of the first and second columns may be output from the output terminal 70 and an average value of the third and fourth columns may be output from an output terminal 71. A difference between the average value of the first and second columns and the average value of the third and fourth columns may be output from an output terminal 72.

In the operation described with reference to Figs. 5 to 10, a reset voltage at the floating diffusion regions may be read to another line memory, prior to reading image signals of pixels. In this case, by using a difference between the reset voltage and the image signal, a variation of output voltages to be caused by a variation of threshold voltages of

transistors 104 can be eliminated. Therefore, an image signal with a high S/N ratio can be obtained which does not contain noise components to be generated by a variation of image signals caused by a variation of amounts of light detected with photodetectors.

Vertical/horizontal scanning may be performed by thinning pixels in the unit of one block or a plurality of blocks so that more compressed image signals can be obtained.

Other photoelectric conversion elements may be used to obtain similar advantages of the above embodiments.

In the above embodiments, a CMOS sensor is used as an example of image pickup elements. Other image pickup elements such as CCD and SIT may also be used.

In the above embodiments, color filters of four colors including yellow Ye, magenta Mg, cyan Cy, and green G are used. Other color filters may also be used if they can obtain a luminance signal and color difference signals.

Fig. 11 is a block diagram showing the structure of an image pickup system with an image pickup apparatus, according to the fifth embodiment of the invention.

Referring to Fig. 11, signals from pixels of an image pickup apparatus 91 such as a CMOS sensor are supplied directly to an A/D converter 92, without

processing the signals such as addition calculation to obtain color difference signals and a luminance signal. After the signals are converted by the A/D converter 92 into digital signals, they are stored in a memory 93. A computer 94 performs necessary calculations for digital signals stored in the memory 93 to obtain a luminance signal and color difference signals. Software for running the computer 94 may be stored in a storage medium storing programs. The storage medium storing such programs may be a floppy disk, a hard disk, an optical disk, a magneto-optical disk, a CD-ROM, a magnetic tape, a semiconductor memory, and a like.

As described so far, according to the embodiments, a color image signal with color difference signals having a high resolution both in the horizontal and vertical directions can be obtained, for example by using the first read method.

According to the embodiments, there are various read modes relative to the same color filer pattern. Accordingly, the embodiments can be applied to a multi-mode such as a mode of outputting an image signal at high speed which signal can be used for simple color display, autofocus, white balance adjustment and a mode of outputting an image signal having a high resolution.

Many widely different embodiments of the present invention may be constructed without departing from the

spirit and scope of the present invention. It should be understood that the present invention is not limited to the specific embodiments described in the specification, except as defined in the appended claims.

WHAT IS CLAIMED IS:

1. An image pickup apparatus comprising:

a plurality of pixels; and

a color filter array of four colors disposed on said plurality of pixels,

wherein said color filter array has a periodicity of two rows × two columns, and colors of four color filters in a periodical unit of two rows × two columns are all different from each other.

2. An image pickup apparatus according to claim 1, wherein the four color filters include a filter of transmitting only green light in a visible light range, a filter of intercepting only blue color in the visible light range, a filter of intercepting only green light in the visible light range, and a filter of intercepting only red light in the visible light range.

3. An image pickup apparatus according to claim 1, further comprising means for performing an operation of A + B - C - D, where A, B, C, and D represent signals picked up from an area of two rows × two columns.

4. An image pickup apparatus according to claim 3, wherein the signals A and B are disposed on a same line or on a same column, and the signals C and D are

disposed on a same line or on a same column.

5. An image pickup apparatus according to claim 3, further comprising means for performing an operation of A + C - B - D.

6. An image pickup apparatus according to claim 5, wherein the signals A and B are disposed on a same line or on a same column, and the signals C and D are disposed on a same line or on a same column.

7. An image pickup apparatus according to claim 1, further comprising means for reading a difference between an addition signal of a first row, first column signal and a first row, second column signal and an addition signal of a second row, first column signal and a second row, second column signal, respectively in an area of two rows × two columns column, and means for reading a difference between an addition signal of a first row, first column signal and a second row, first column signal and an addition signal of a first row, second column signal and a second row, second column signal, respectively in the area of two rows × two columns column.

8. An image pickup apparatus according to claim 7, wherein the areas of two rows × two columns are

disposed without any space therebetween.

9. An image pickup apparatus according to claim 1, further comprising means for reading an addition signal of all signals in an area of four rows × one column.

10. An image pickup apparatus according to claim 1, further comprising means for reading an addition signal of all signals in an area of one row × four columns.

11. An image pickup apparatus comprising:

a plurality of pixels;

a color filter array of four colors disposed on said plurality of pixels and having a periodicity of two rows × two columns; and

calculating means for calculating two color difference signals from each color filter of two rows × two columns in said color filter array having the periodicity of two rows × two columns.

12. An image pickup apparatus according to claim 11, wherein said calculating means performs an operation of A + B - C - D, where A, B, C, and D represent signals picked up from an area of two rows × two columns.

13. An image pickup apparatus according to claim 12, wherein the signals A and B are disposed on a same line or on a same column and the signals C and D are disposed on a same line or on a same column.

14. An image signal read method of reading an image signal from the image pickup apparatus recited in claim 1, wherein an image signal is read by performing an operation of A + B - C - D, where A, B, C, and D represent signals picked up from an area of two rows × two columns.

15. An image signal read method according to claim 14, wherein the signals A and B are disposed on a same line or on a same column, and the signals C and D are disposed on a same line or on a same column.

16. An image signal read method according to claim 14, wherein an image signal is read by performing an operation of A + C - B - D.

17. An image signal read method according to claim 16, wherein the signals A and B are disposed on a same line or on a same column, and the signals C and D are disposed on a same line or on a same column.

18. An image signal read method of reading an

image signal from the image pickup apparatus recited in claim 1, wherein a difference between an addition signal of a first row, first column signal and a first row, second column signal and an addition signal of a second row, first column signal and a second row, second column signal, respectively in an area of two rows × two columns column, is read as a first color difference signal, and a difference between an addition signal of a first row, first column signal and a second row, first column signal and an addition signal of a first row, second column signal and a second row, second column signal, respectively in the area of two rows × two columns column, is read as a second color difference signal.

19. An image signal read method according to claim 15, wherein the areas of two rows × two columns are disposed without any space therebetween.

20. An image signal read method of reading an image signal from the image pickup apparatus recited in claim 1, wherein an addition signal of all signals in an area of four rows × two columns is read as a luminance signal.

21. An image signal read method of reading an image signal from the image pickup apparatus recited in

claim 1, wherein an addition signal of all signals in an area of two rows × four columns is read as a luminance signal.

22. An image pickup apparatus comprising:

a plurality of pixels;

a color filter array of four colors disposed on said plurality of pixels;

first calculating means for calculating a difference between an average signal of a first row, first column signal and a first row, second column signal in an area of two rows × two columns and an average signal of a second row, first column signal and a second row, second column signal in the area of two rows × two columns; and

second calculating means for calculating a difference between an average signal of a first row, first column signal and a second row, first column signal in the area of two rows × two columns and an average signal of a first row, second column signal and a second row, second column signal in the area of two rows × two columns.

23. An image pickup apparatus according to claim 22, wherein:

said first calculating means comprises first storing means for storing the first row, first column

signal, second storing means for storing the first row, second column signal, third storing means for storing the second row, first column signal, fourth storing means for storing the second row, second column signal, first averaging means for averaging the signals stored in said first and second storage means, second averaging means for averaging the signals stored in said third and fourth storage means, and first difference calculating means for calculating a difference between an averaged signal of the signals stored in said first and second storage means and an averaged signal of the signals stored in said third and fourth storage means; and

said second calculating means comprises fifth storing means for storing the first row, first column signal, sixth storing means for storing the second row, first column signal, seventh storing means for storing the first row, second column signal, eighth storing means for storing the second row, second column signal, third averaging means for averaging the signals stored in said third and fourth storage means, fourth averaging means for averaging the signals stored in said fifth and sixth storage means, and second difference calculating means for calculating a difference between an averaged signal of the signals stored in said fifth and sixth storage means and an averaged signal of the signals stored in said seventh

and eighth storage means.

24. An image signal processing apparatus for the image pickup apparatus recited in claim 1, comprising means for performing an operation of A + B - C - D, where A, B, C, and D represent signals picked up from an area of two rows × two columns.

25. An image signal processing apparatus according to claim 24, wherein the signals A and B are disposed on a same line or on a same column, and the signals C and D are disposed on a same line or on a same column.

26. An image signal processing apparatus according to claim 24, further comprising means for performing an operation of A + C - B - D.

27. An image signal processing apparatus according to claim 26, wherein the signals A and B are disposed on a same line or on a same column, and the signals C and D are disposed on a same line or on a same column.

28. An image signal processing method for the image pickup apparatus recited in claim 1, comprising a step of performing an operation of A + B - C - D, where

A, B, C, and D represent signals picked up from an area of two rows × two columns.

29. An image signal processing method according to claim 28, wherein the signals A and B are disposed on a same line or on a same column, and the signals C and D are disposed on a same line or on a same column.

30. An image signal processing method according to claim 28, comprising a step of performing an operation of A + C - B - D.

31. An image signal processing method according to claim 30, wherein the signals A and B are disposed on a same line or on a same column, and the signals C and D are disposed on a same line or on a same column.

32. A computer readable storage medium storing a program for the image pickup apparatus recited in claim 1, wherein the program performs an operation of A + B - C - D, where A, B, C, and D represent signals picked up from an area of two rows × two columns.

33. A computer readable storage medium according to claim 32, wherein the signals A and B are disposed on a same line or on a same column, and the signals C and D are disposed on a same line or on a same column.

34. A computer readable storage medium according to claim 32, wherein the program further includes a program of performing an operation of A + C - B - D.

35. A computer readable storage medium according to claim 34, wherein the signals A and B are disposed on a same line or on a same column, and the signals C and D are disposed on a same line or on a same column.

36. An image pickup system comprising the image pickup apparatus recited in claim 1 and the image signal processing apparatus recited in claim 24.

37. An image pickup system comprising the image pickup apparatus recited in claim 1 and the image signal processing apparatus recited in claim 26.

ABSTRACT OF THE DISCLOSURE

An image pickup apparatus having a plurality of pixels; and a color filter array of four colors disposed on the plurality of pixels, wherein the color filter array has a periodicity of two rows × two columns, and colors of four color filters in a periodical unit of two rows × two columns are all different.

FIG. 1

	C1	C2	C3	C4
R1	Cy	Ye	Cy	Ye
R2	Mg	G	Mg	G
R3	Cy	Ye	Cy	Ye
R4	G	Mg	G	G
R5	Cy	Ye	Cy	Ye

FIG. 2

	C1	C2
R1	Cy	Y
R2	Mg	G
R3	Cy	Ye
R4	Mg	G
R5	Cy	Ye
R6	G	Mg
R7	C	Ye
R8	G	Mg

FIG. 3

G	Ye
Cy	Mg

FIG. 4

G_1	Ye_1	G_2	Ye_2
Cy_1	Mg_1	Cy_2	Mg_2
G_3	Ye_3	G_4	Ye_4
Cy_3	Mg_3	Cy_4	Mg_4

FIG. 5

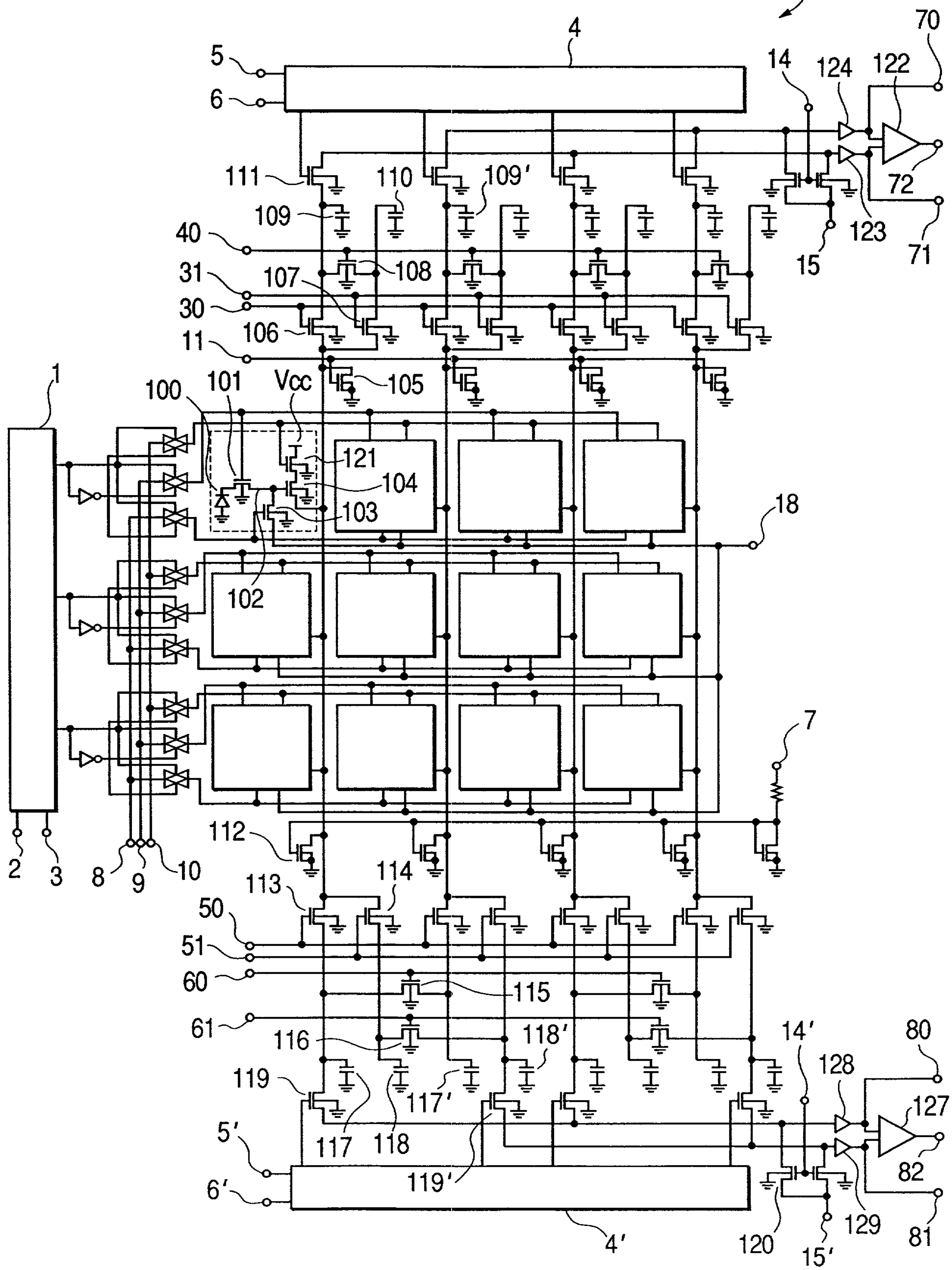
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FIG. 6

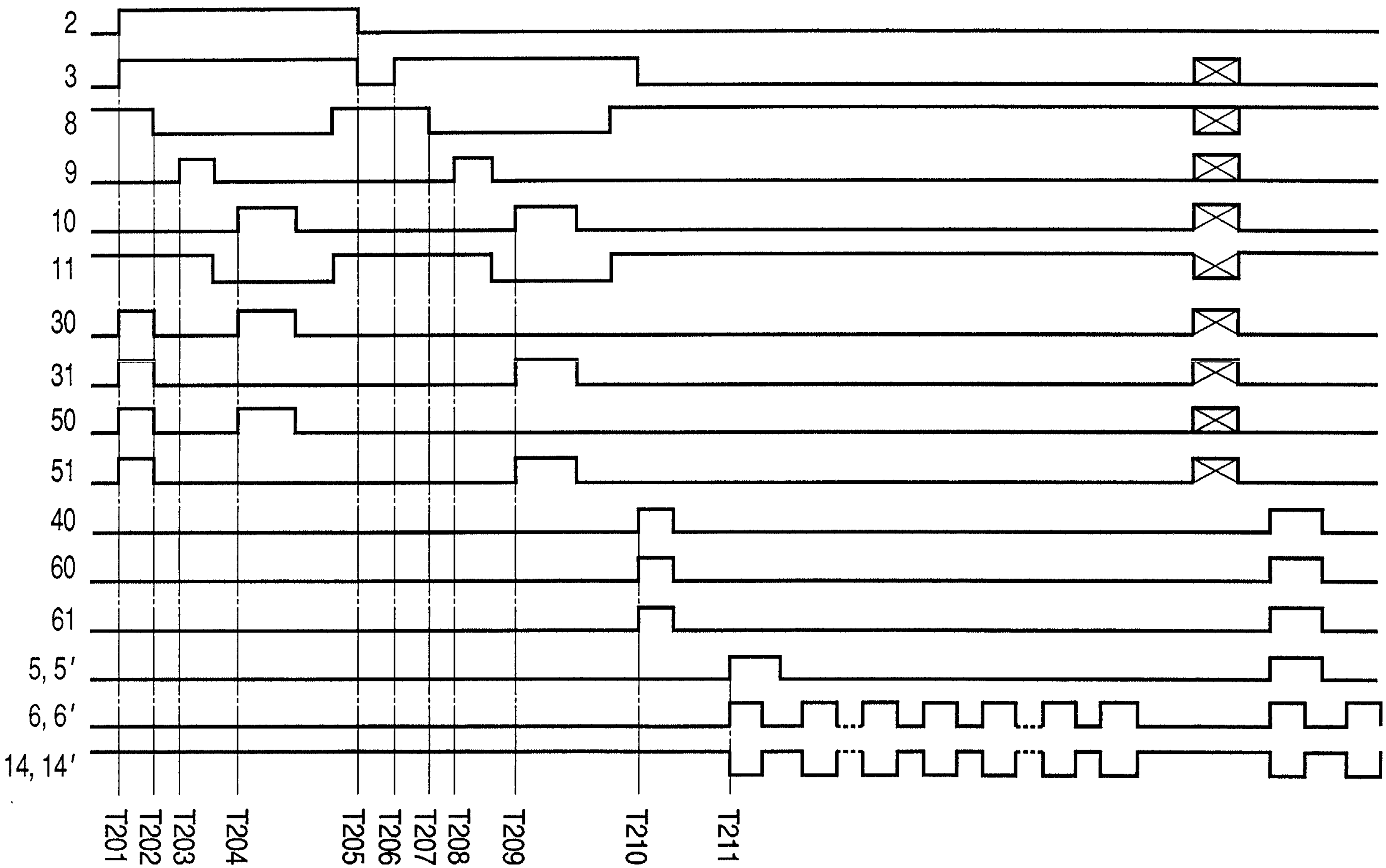
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FIG. 7

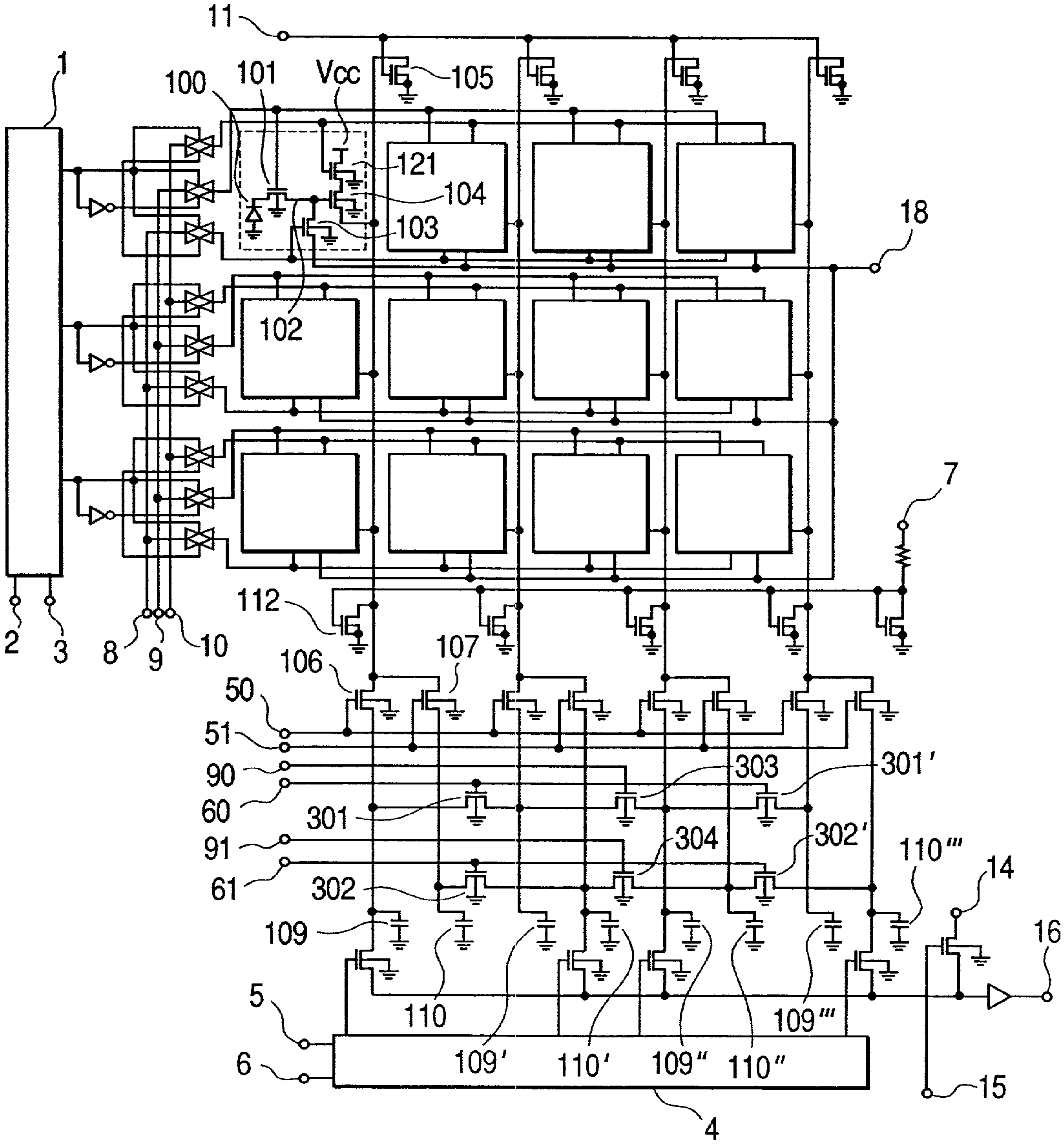

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FIG. 8

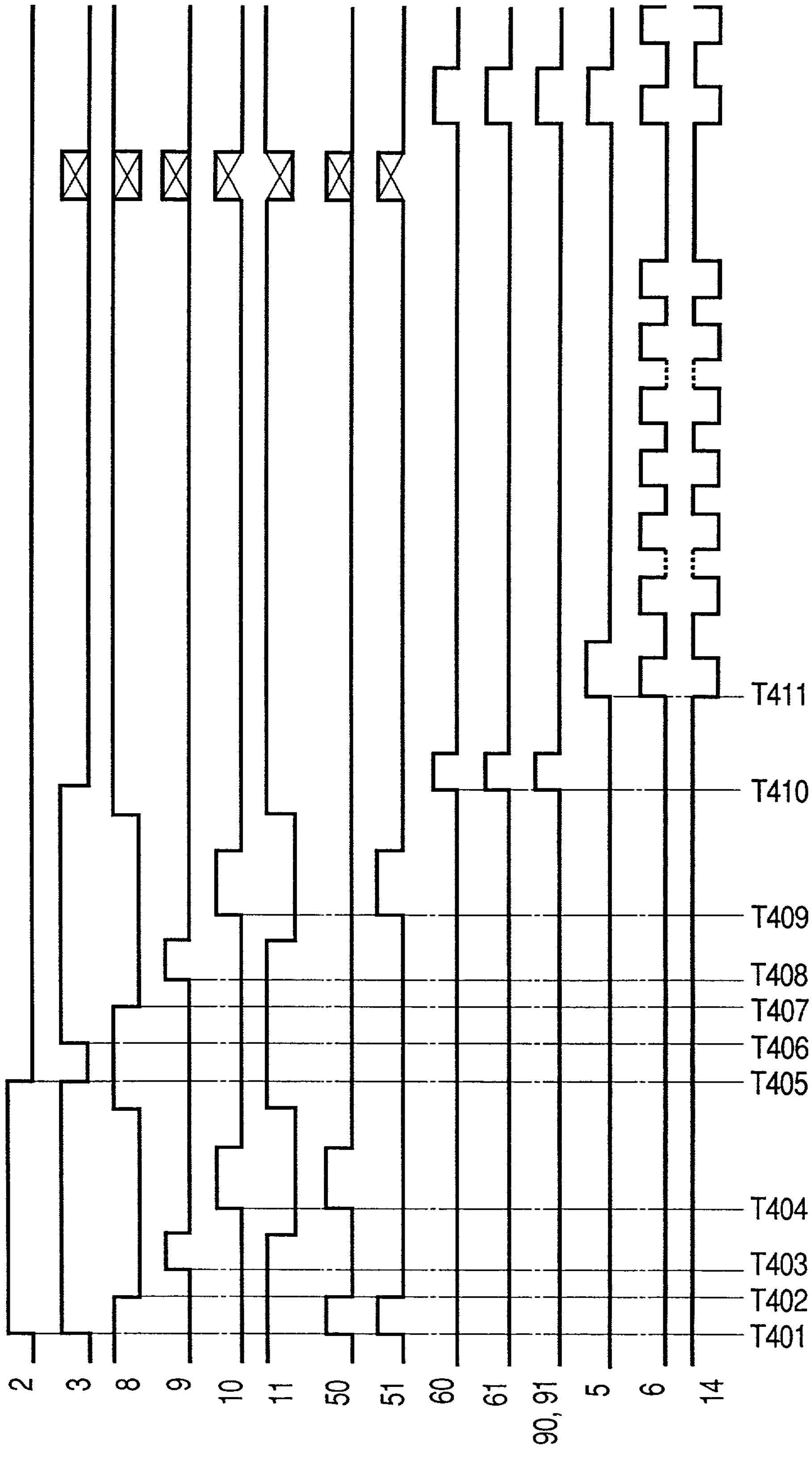

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FIG. 9

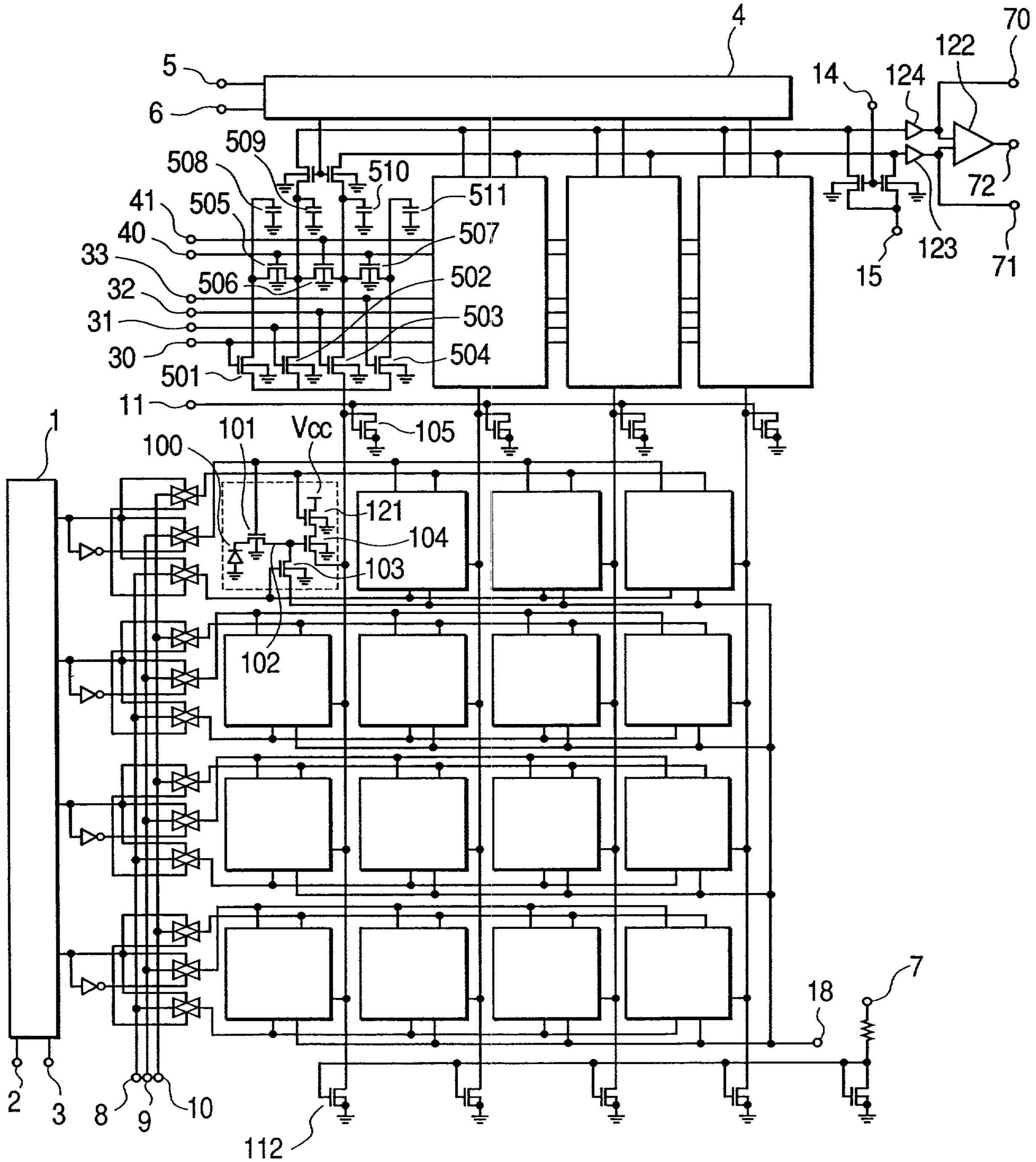
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FIG. 10

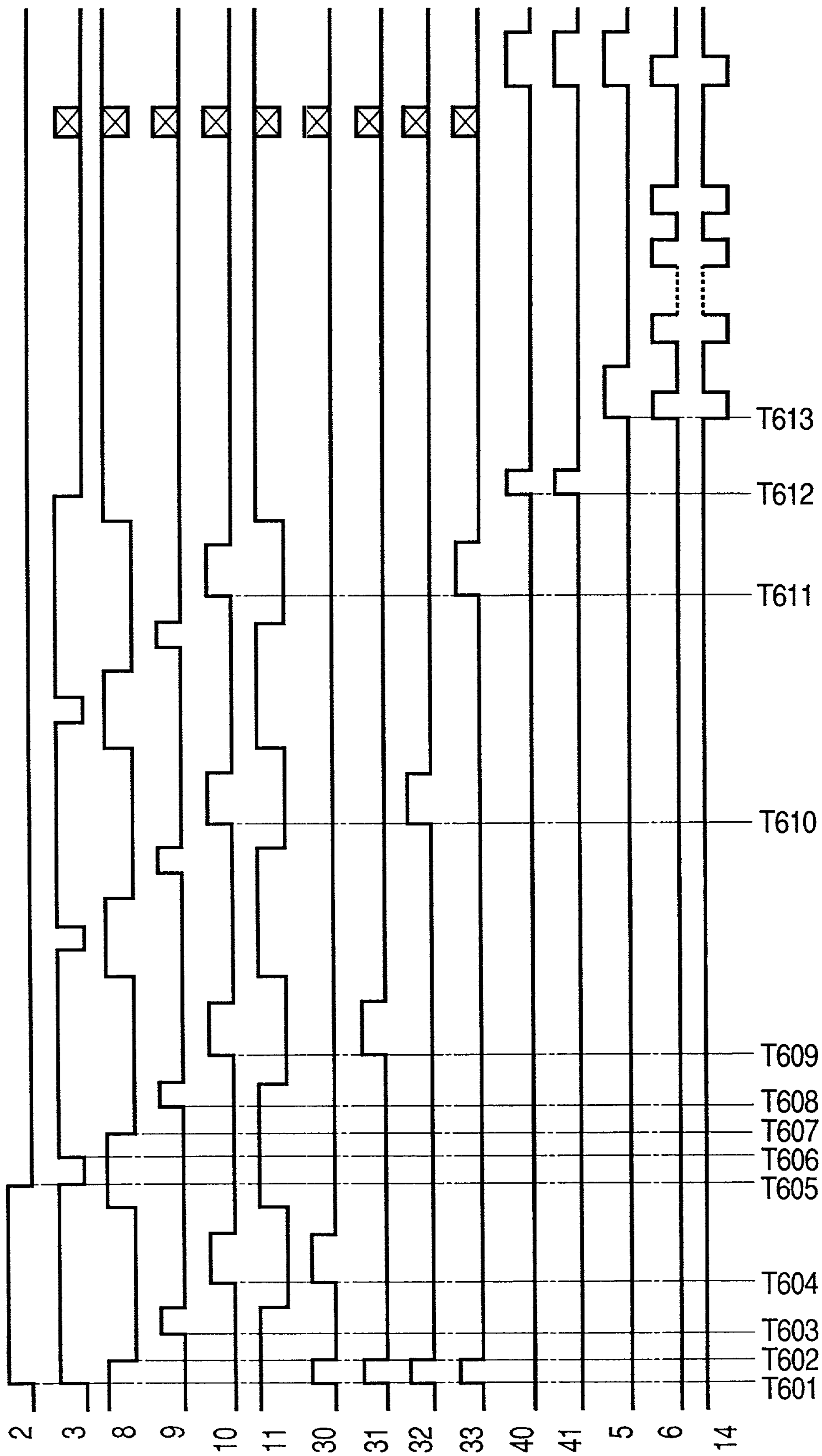
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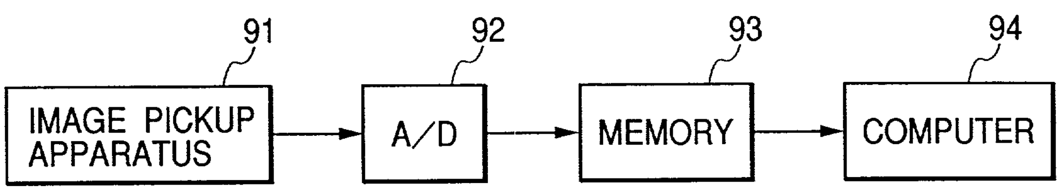
FIG. 11



COMBINED DECLARATION AND POWER OF ATTORNEY
FOR PATENT APPLICATION
(Page 1)

As a below named inventor, I hereby declare that

My residence, post office address and citizenship are as stated below next to my name;

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled ____________ IMAGE PICKUP APPARATUS ____________,

the specification of which [X] is attached hereto [ ] was filed on ____________ as United States Application No or PCT International Application No. ____________ and was amended on ____________ (if applicable)

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR §1 56

I hereby claim foreign priority benefits under 35 U.S C §119(a)-(d) or §365(b), of any foreign application(s) for patent or inventor's certificate, or § 365(a) of any PCT international application which designates at least one country other than the United States, listed below and have also identified below any foreign application for patent or inventor's certificate, or PCT international application having a filing date before that of the application on which priority is claimed.

Country	Application No	Filed (Day/Mo /Yr)	(Yes/No) Priority Claimed
Japan	10-018813	January 30, 1998	Yes

I hereby claim the benefit under 35 U.S C § 120 of any United States application(s), or § 365(c) of any PCT international application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT international application in the manner provided by the first paragraph of 35 U S.C § 112, I acknowledge the duty to disclose information which is material to patentability as defined in 37 C F R § 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application

	Application No	Filed (Day/Mo /Yr)	Status (Patented, Pending, Abandoned)
N/A			

I hereby appoint the practitioners associated with the firm and Customer Number provided below to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith, and direct that all correspondence be addressed to the address associated with that Customer Number

FITZPATRICK, CELLA, HARPER & SCINTO
Customer Number: 05514

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true, and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon

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COMBINED DECLARATION AND POWER OF ATTORNEY
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(Page 2)

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